Quiz 2 Key
BI-374, Spring '06, Dr. C. S. Tritt

Point values are as follows: 4 to 12 are worth 10 points each, 13 and 14 are worth 20 points each total is divided by 1.3 to put in on a 100 point basis. The first 3 problems were not on the announced material and were omitted. Scores were not good: high 89, low 45, average 72.

A general comment: Stop “backing” into your answers. There will be less to learn if you focus on only the important stuff (as is defined by the learning objectives). However, having the “big picture” (particularly with regard to functions and mechanisms) provides a framework into which to place what you are learn and thereby makes the “memorization” easier. I try to test for an in depth but practical understand of the key material covered.

1. Sketch a spirogram (lung volume versus time plot) and clearly label the following quantities: FRC, TV, IC, TLC, RV and VC.

2. Briefly explain the mechanical significance of the FRC volume.

3. Explain the function of the natural surfactant in the lungs. You response should be relatively specific and include at least a mention of Laplace's equation ($P = 2T/r$).

4. Describe the effect of local hypoxia on local blood flow in the lungs and explain the functional significance of this response.

Local hypoxia causes vasoconstriction in the lungs. This reduces perfusion of under ventilated parts of the lungs and thus helps maintain uniformly optimal ventilation to perfusion ($\dot{V}/Q$) ratios.

5. Explain how exercise effects the distribution of ventilation perfusion ratios in the lungs and the functional significance of this behavior.

Exercise evens out the distribution of ventilation to perfusion ratios in the lungs (i.e., makes it more uniform). This is all that was needed. Not addressing the distribution (either directly or indirectly) was -5.

6. Briefly define each of the following conditions and/or explain the difference between them: *hypoxic hypoxia*, *anemic hypoxia*, *ischemic (*a.k.a. *circulatory) hypoxia* and *histotoxic hypoxia*.

Hypoxic – Hypoxia resulting from low O_2 concentration that is the direct result of low P_{O2} in the blood.

Anemic – Hypoxia resulting from low O_2 concentration with a normal P_{O2}. This may be the result of low Hb concentration or Hb dysfunction (say as the result of CO poisoning).

Ischemic – Hypoxia resulting from low blood flow.

Histoxic – Hypoxia resulting from the inability of cells to use O_2. A classic example of this is cyanide poisoning.

7. Explain the concept of *physiological shunt* (as opposed to anatomical shunt) in the lungs.

Physiologic shunt is the **effective** bypassing of gas exchange by blood passing through the lungs. It is the result of the distribution of ventilation-perfusion mismatches in lungs. In some parts of the lungs, the blood passes through alveoli in which the P_{O2} is too low to fully saturate it while in other parts of the lungs, the P_{O2} in the alveoli is much higher than is necessary to produce saturation and is thus effectively wasted.

This is more than just the blood not being fully saturated (oxygenated) while passing through the lungs (although this is the typical result of a significant shunt fraction). If a subject were breathing air with a reduced amount of O_2 in it, they could have an arterial saturation of well below 100% while having no significant physiologic or anatomical shunt.

Not saying or at least implying effective or define anatomical shunt (which is the fraction of blood actually (physically) bypassing the alveoli) was -5.

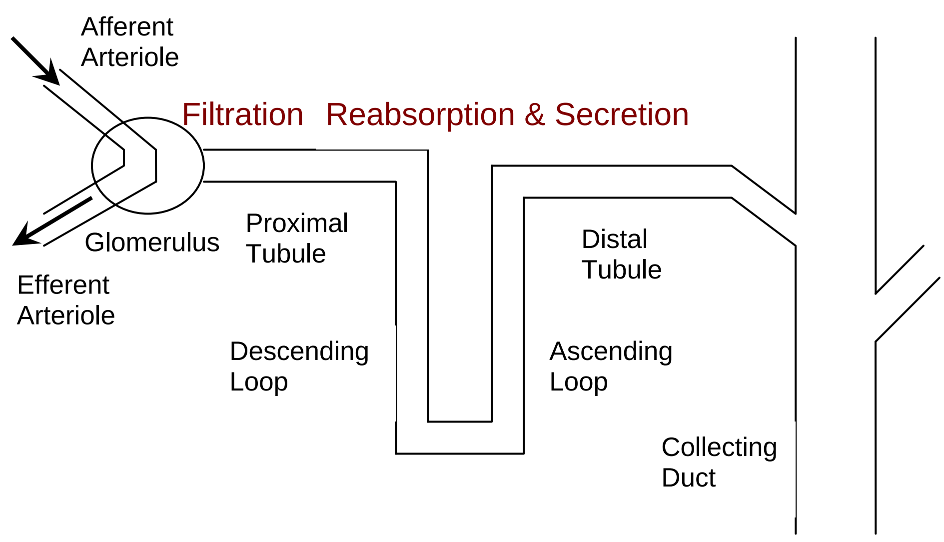
8. Name and describe the primary role of each type of the two types of chemoreceptors in the control of ventilation.

Central – in the brain, senses mainly P_{CO2}, also senses P_{O2} in extreme cases, does not respond to plasma pH because of the blood-brain barrier.

Peripheral – in the aorta and carotid bodies, senses plasma pH and P_{O2}, relatively insensitive to plasma P_{CO2} directly (but responds to it indirectly via pH changes).

9. Sketch a typical nephron, label it major parts and name or briefly describe the processes that occur in each of these parts.

See Slides 8 and 13 in the Renal1 show. Sketch worth 3 points. Each item or process worth a point (-2 if misplaced).



10. Explain the phenomena of “transport maximum” in some detail.

There is a maximum rate at which many materials can be reabsorbed or secreted in the renal tubules. This maximum is the result of the finite number of transport protein molecules involved and the finite rate at which each of these molecules can physically move. If the filtered load of a substance exceeds its transport maximum the portion of it not reabsorbed will appear in the urine. This commonly occurs in untreated diabetes for glucose.

11. Name a hormone that affects renal function and describe a major stimulus for its release (generally the physiology parameter it regulates) and the hormone’s mechanism of action.

This could have been any of the ones covered in class (rennin-angiotensin system, ANF, ADH, or aldosterone). The name was worth 3 points, the stimulus for release worth 4 and the mechanism of action worth 3.

12. Explain a major process or mechanism involved in the autoregulation of the GFR.

I accepted either a description of the tubular-glomerular process (the one involving sensing of excess Na^+ in the tubule fluid by the JGA (see Slide 5 in the Renal2 show) or the myogenic response described in the book.

13. Calculate a test subject’s “final” osmolarity, ICF volume and ECF volume after the infusion of 2 liters of 280 mOsm/liter saline (NaCl) solution given that his initial osmolarity was 300 mOsm/liter, ICF volume was 28.0 liters and ECF volume was 12 liters.

The initial ICF and ECF volumes and osmolarity are:

ICF volume	28.0 l
ECF volume	12.0 l
Osmolarity	300 mOsm/kg H_2O

Assume a constant density of 1.00 kg/l for the solution and neglect the mass of the solute so values of molality (moles/kg H_2O) and molarity (moles/l of solution) are the same. Assume a period long enough for establishment of osmotic equilibrium but short enough that renal and other compensatory responses do not occur. So,

Initial osmoles:

IC osmoles = (28.0 l)(300 mOsm/l) = 8400mOsm
EC osmoles = (12.0 l)(300 mOsm/l) = 3600mOsm

Addition of 2.0 l of 280 mOsm/l saline (NaCl).

		Initial	Final
Volumes (liters)	IC	28.0	28.1
	EC	12.0	13.9
	TB	40.0	42.0

Osmoles (Osm)	IC	8400	8400 (n.c.)
	EC	3600	4160
	TB	12000	12560
Osm/l		300	299

Added volume: 2.0 l
Added osmoles: (2.0 l)(280 mOsm/l) = 560 mOsm all of which stays in the ECF.
Final EC osmoles: 3600 + 560 mOsm = 4160 mOsm.
Total body osmoles: 8400 + 4160 mOsm = 12560 mOsm.
Final osmolarity: 12560 mOsm/42 liters = 299 mOsm.
IC volume: (8400 mOsm)/(299 mOsm) = 28.1 liters.
EC volume: 42.0 – 28.1 liter = 13.9 liters.

14. Calculate a the clearance of an experimental drug from a patient's blood given the following data: drug concentration in the plasma 120 µg/dl, drug concentration in the urine 120 µg/ml, urine formation rate 0.80 ml/min. At the same time, the patient's inulin clearance was determined to be 110 ml/min. Given that the experimental drug is known to be freely filtered, comment on whether these results indicates it is secreted, reabsorbed or ignored in the renal tubules.

$C_{drug} = V*U_{drug}/P_{drug}$ = [(0.80 ml/min)(120 µg/ml)/(120 µg/dl)](100ml/dl) = 80.0 ml/min (14 pts)

C_{inulin} = GFR = 110 ml/min

Since we were told the drug is freely filtered, C_{drug} < GFR implies the drug is reabsorbed in the tubules. (6 pts) Units conversion problems -3.